Configuring DHCP Step 1: Excluding IP Addresses

```
R1(config)#ip dhcp excluded-address low-address [high-address]
```

```
R1(config)#ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)#ip dhcp excluded-address 192.168.10.254
```

Configuring DHCP Step 2: Configuring a DHCP Pool

```
R1(config)#ip dhcp pool pool-name
```

```
R1(config)#ip dhcp pool LAN-POOL-1
R1(dhcp-config)#
```

Configuring DHCP Step 3: Specific Tasks

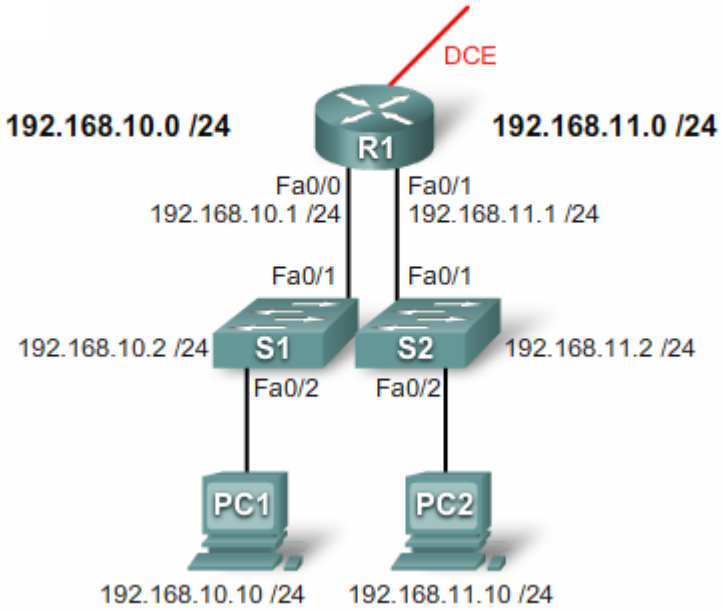
Required Tasks	Command
Define the address pool	`network network-number [mask | /prefix-length]`
Define the default router or gateway	`default-router address [address2...address8]`

Optional Tasks	Command
Define a DNS server.	`dns-server address [address2...address8]`
Define the domain name	`domain-name domain`
Define the duration of the DHCP lease	`lease { days [hours] [minutes] | infinite}`
Define the NetBIOS WINS server	`netbios-name-server address [address2...address8]`

DHCP Configuration Example

```
R1(config)# ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)# ip dhcp excluded-address 192.168.10.254
R1(config)# ip dhcp pool LAN-POOL-1
R1(dhcp-config)# network 192.168.10.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.10.1
R1(dhcp-config)# domain-name span.com
R1(dhcp-config)# end
```

DHCP Sample Topology



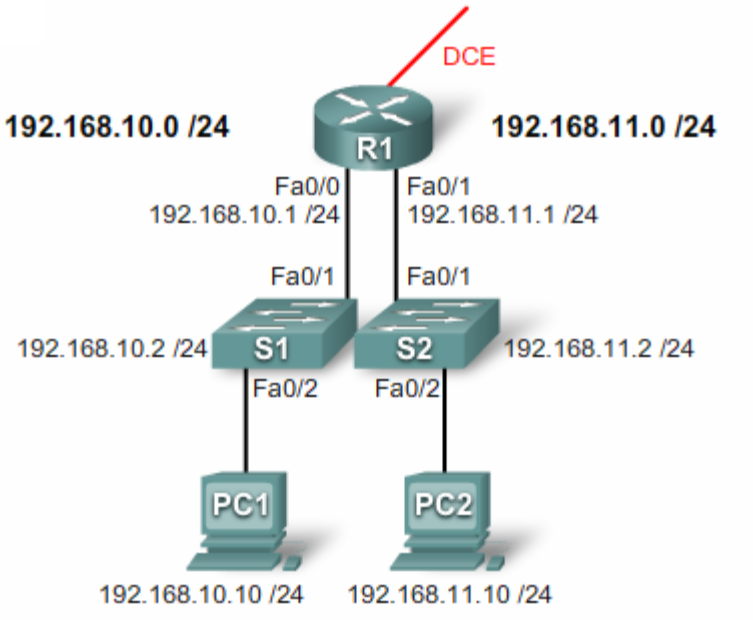
Verifying DHCP-1

```
R1#show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/              Lease expiration        Type
                    Hardware address/
                    User name

R1#show ip dhcp server statistics
Memory usage         23543
Address pools        1
Database agents      0
Automatic bindings   0
Manual bindings      0
Expired bindings     0
Malformed messages   0
Secure arp entries   0

Message              Received
BOOTREQUEST          0
DHCPDISCOVER         0
DHCPREQUEST          0
DHCPDECLINE          0
DHCPRELEASE          0
DHCPINFORM           0

Message              Sent
BOOTREPLY            0
DHCPOFFER            0
DHCPACK              0
DHCPNAK              0
R1#
```

Verifying DHCP-1

```
R1#show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/              Lease expiration        Type
                    Hardware address/
                    User name
192.168.10.10       0100.e018.5bdd.35       Oct 03 2007 05:05 PM    Automatic

R1#show ip dhcp server statistics
Memory usage         23786
Address pools        1
Database agents      0
Automatic bindings   1
Manual bindings      0
Expired bindings     0
Malformed messages   0
Secure arp entries   0

Message              Received
BOOTREQUEST          0
DHCPDISCOVER         6
DHCPREQUEST          1
DHCPDECLINE          0
DHCPRELEASE          0
DHCPINFORM           0

Message              Sent
BOOTREPLY            0
DHCPOFFER            1
DHCPACK              1
DHCPNAK              0
R1#
```

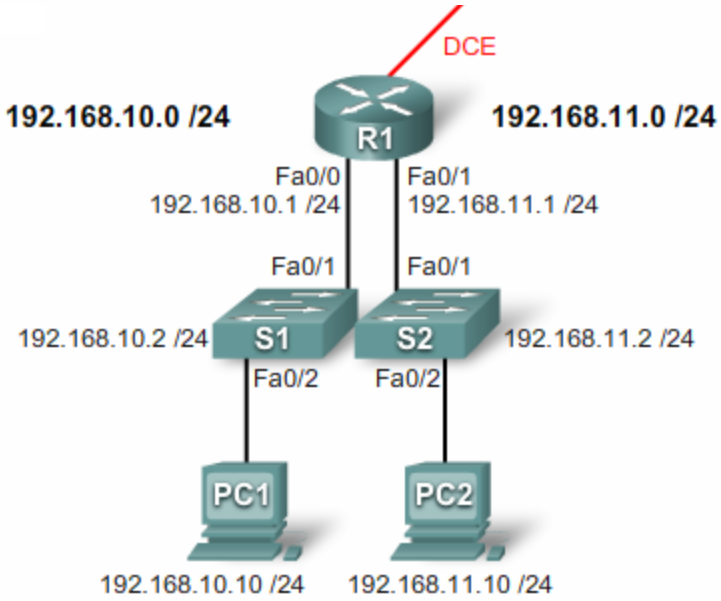
DHCP Sample Topology



DHCP Client

```
C:\WINDOWS\system32\cmd.exe
C:\Documents and Settings\SpanPC>ipconfig /all

Windows IP Configuration

        Host Name . . . . . . . . . . . . : ciscolab
        Primary Dns Suffix . . . . . . . :
        Node Type . . . . . . . . . . . . : Unknown
        IP Routing Enabled. . . . . . . . : No
        WINS Proxy Enabled. . . . . . . . : No

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix . : span.com
        Description . . . . . . . . . . . : SiS 900 PCI Fast Ethernet Adapter
        Physical Address. . . . . . . . . : 00-E0-18-5B-DD-35
        Dhcp Enabled. . . . . . . . . . . : Yes
        Autoconfiguration Enabled . . . . : Yes
```

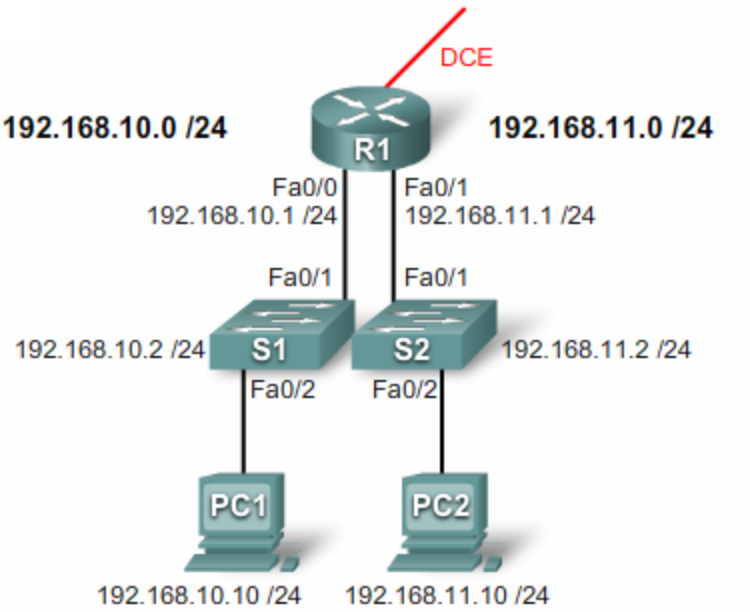
Sample Topology



Verifying DHCP-3

```
R1#sho ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/              Lease expiration        Type
                    Hardware address/
                    User name
192.168.10.10       0100.e018.5bdd.35       Oct 03 2007 06:14 PM    Automatic
192.168.11.10       0100.b0d0.d817.e6       Oct 03 2007 06:18 PM    Automatic


R1#sho ip dhcp server statistics
Memory usage         25307
Address pools        2
Database agents      0
Automatic bindings   2
Manual bindings      0
Expired bindings     0
Malformed messages   0
Secure arp entries   0

Message              Received
BOOTREQUEST          0
DHCPDISCOVER         8
DHCPREQUEST          3
DHCPDECLINE          0
DHCPRELEASE          0
DHCPINFORM           0

Message              Sent
BOOTREPLY            0
DHCPOFFER            3
DHCPACK              3
DHCPNAK              0
R1#
```

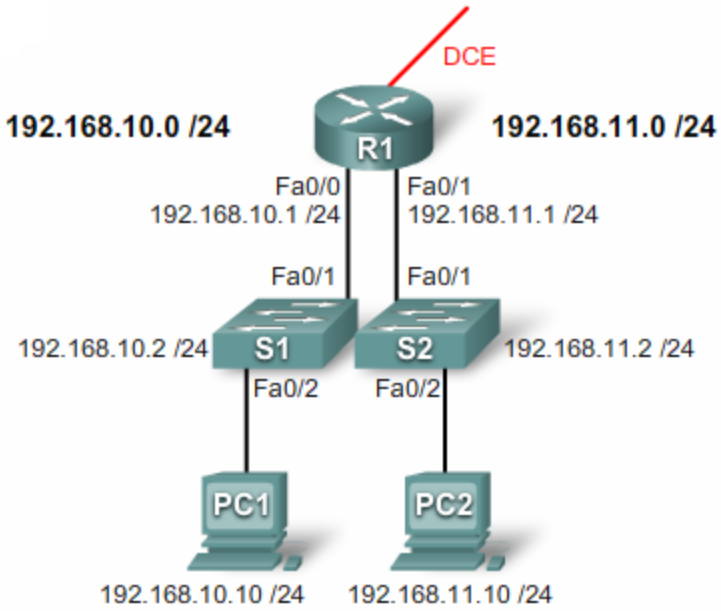
DHCP Sample Topology



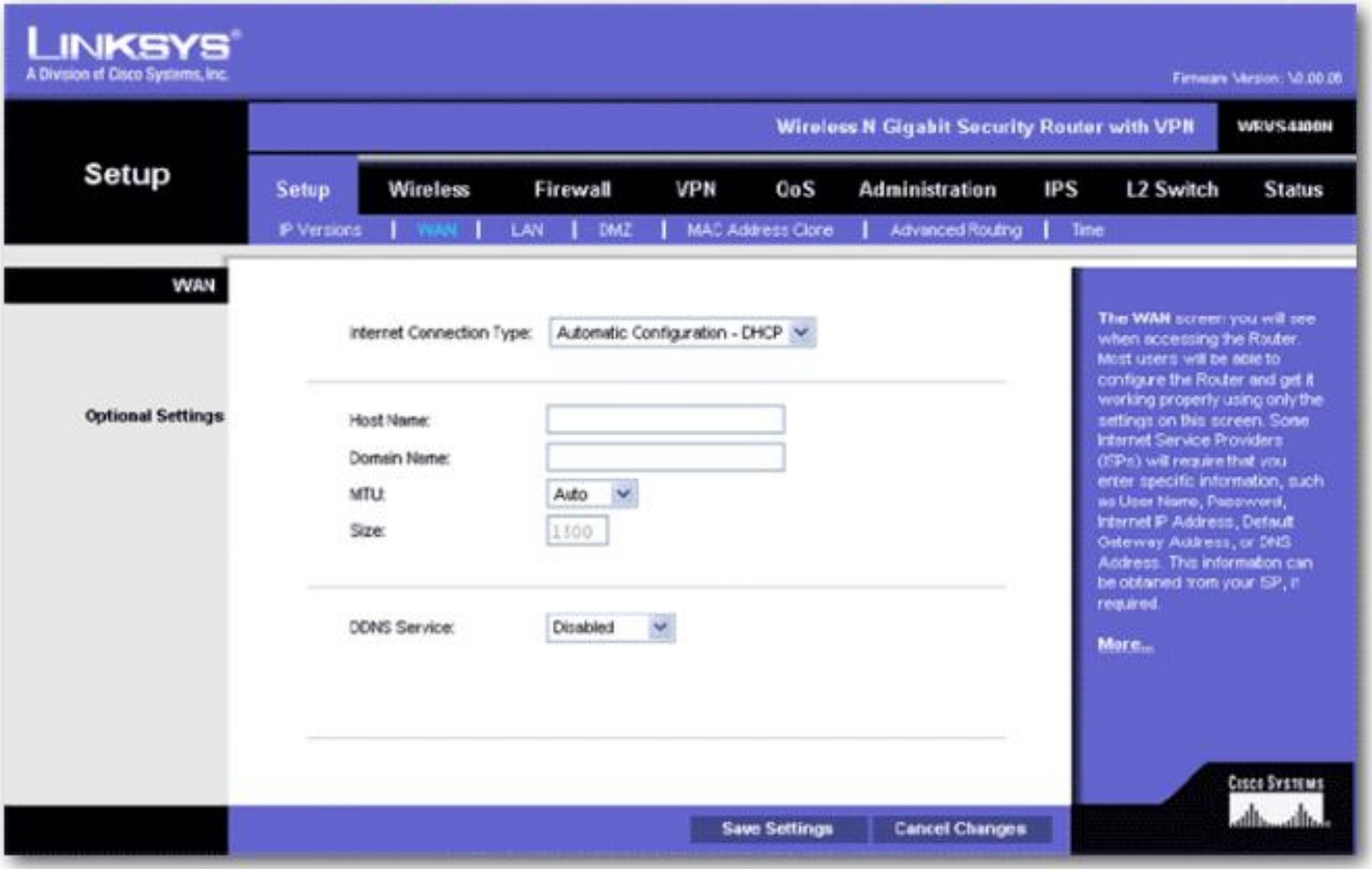
Verifying DHCP Pools

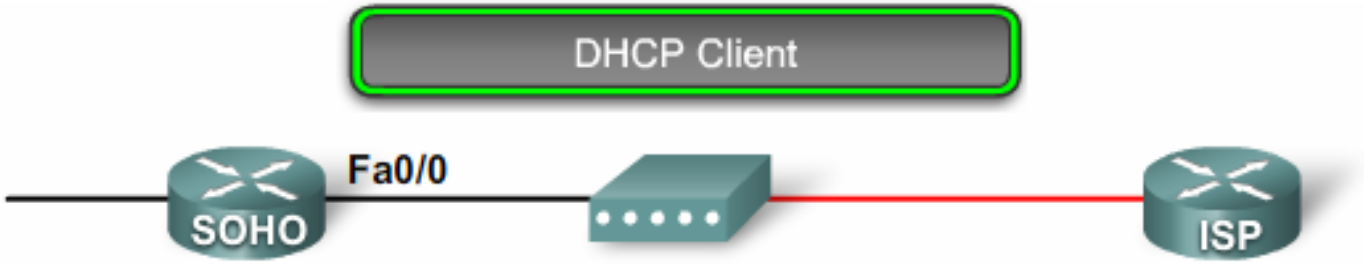
```
R1#show ip dhcp pool

Pool LAN-POOL-1 :
 Utilization mark (high/low)    : 100 / 0
 Subnet size (first/next)       : 0 / 0
 Total addresses                : 254
 Leased addresses               : 1
 Pending event                  : none
 1 subnet is currently in the pool :
 Current index        IP address range                    Leased addresses
 192.168.10.11        192.168.10.1     - 192.168.10.254    1

Pool LAN-POOL-2 :
 Utilization mark (high/low)    : 100 / 0
 Subnet size (first/next)       : 0 / 0
 Total addresses                : 254
 Leased addresses               : 1
 Pending event                  : none
 1 subnet is currently in the pool :
 Current index        IP address range                    Leased addresses
 192.168.11.11        192.168.11.1     - 192.168.11.254    1
R1#
```

DHCP Sample Topology



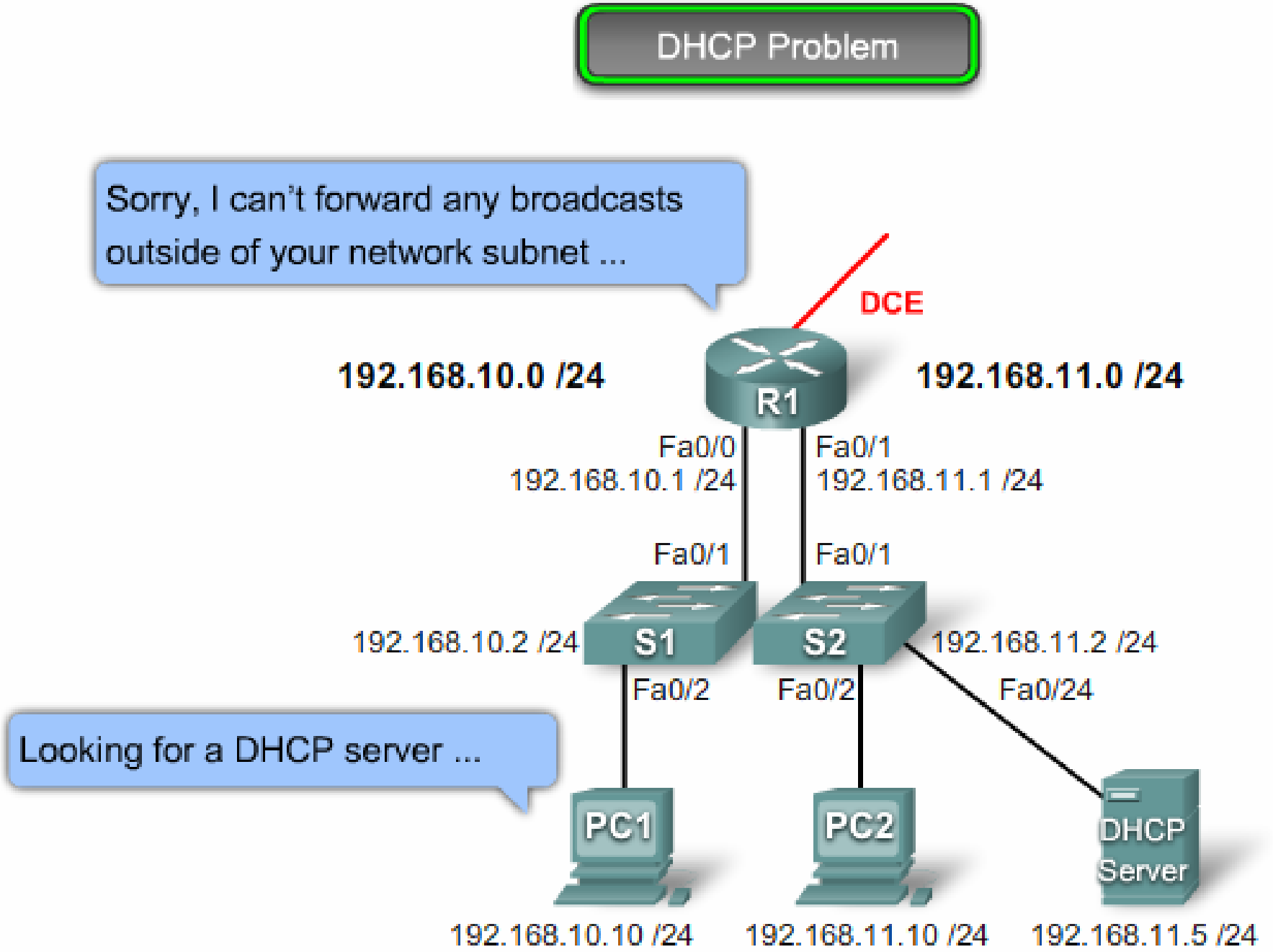
Linksys Router





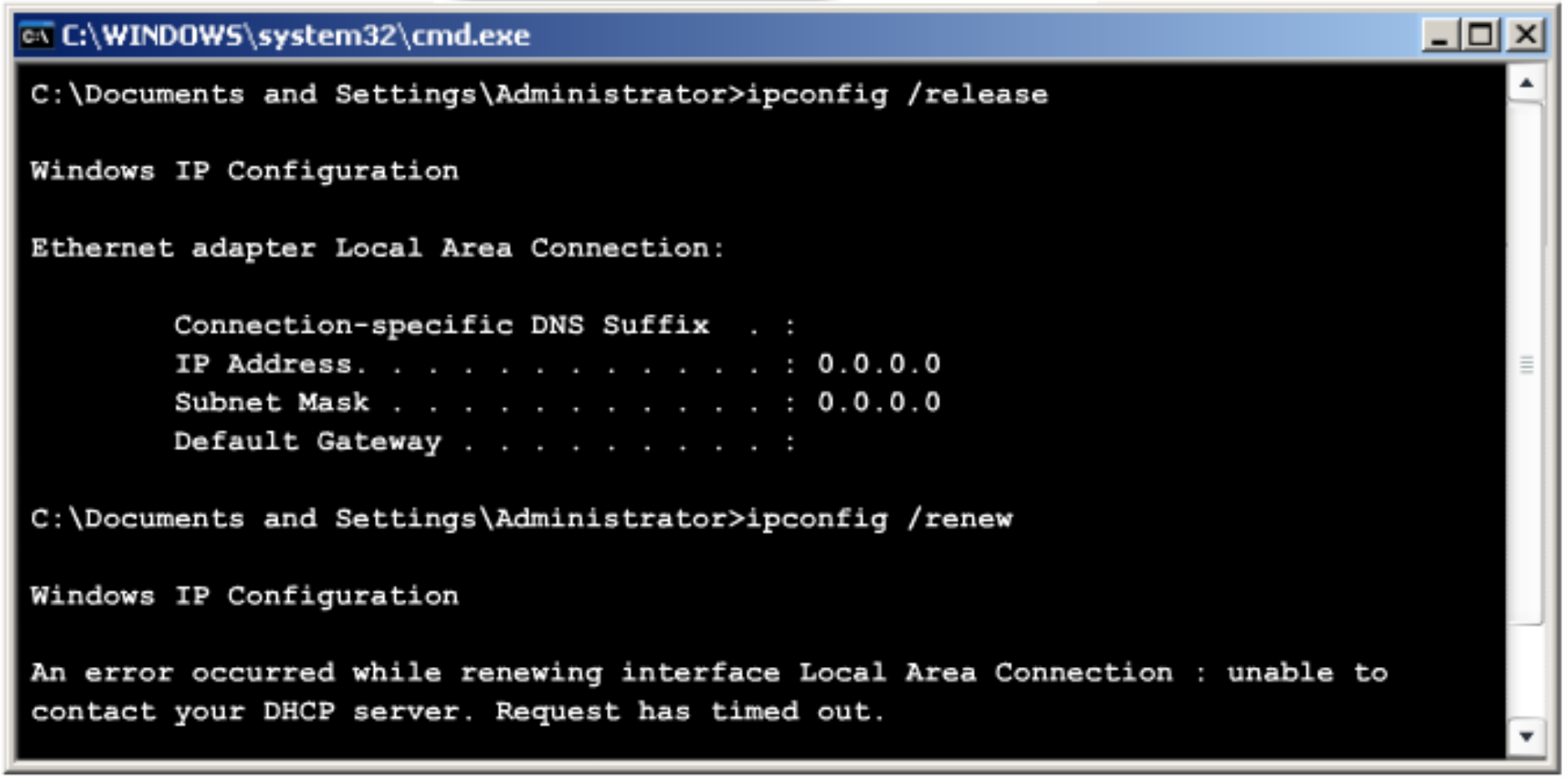

```
SOHO(config)# interface fa0/0
SOHO(config-if)# ip address dhcp
SOHO(config-if)# no shut
SOHO(config-if)#
*Oct  2 17:57:36.027: %DHCP-6-ADDRESS_ASSIGN: Interface FastEthernet0/0 assigned
 DHCP address 209.165.201.12, mask 255.255.255.224, hostname SOHO

SOHO# show ip int fa0/0
FastEthernet0/0 is up, line protocol is up
  Internet address is 209.165.201.12/27
  Broadcast address is 255.255.255.255
  Address determined by DHCP from host 209.165.201.1
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled

<Output omitted>
```

DHCP Problem



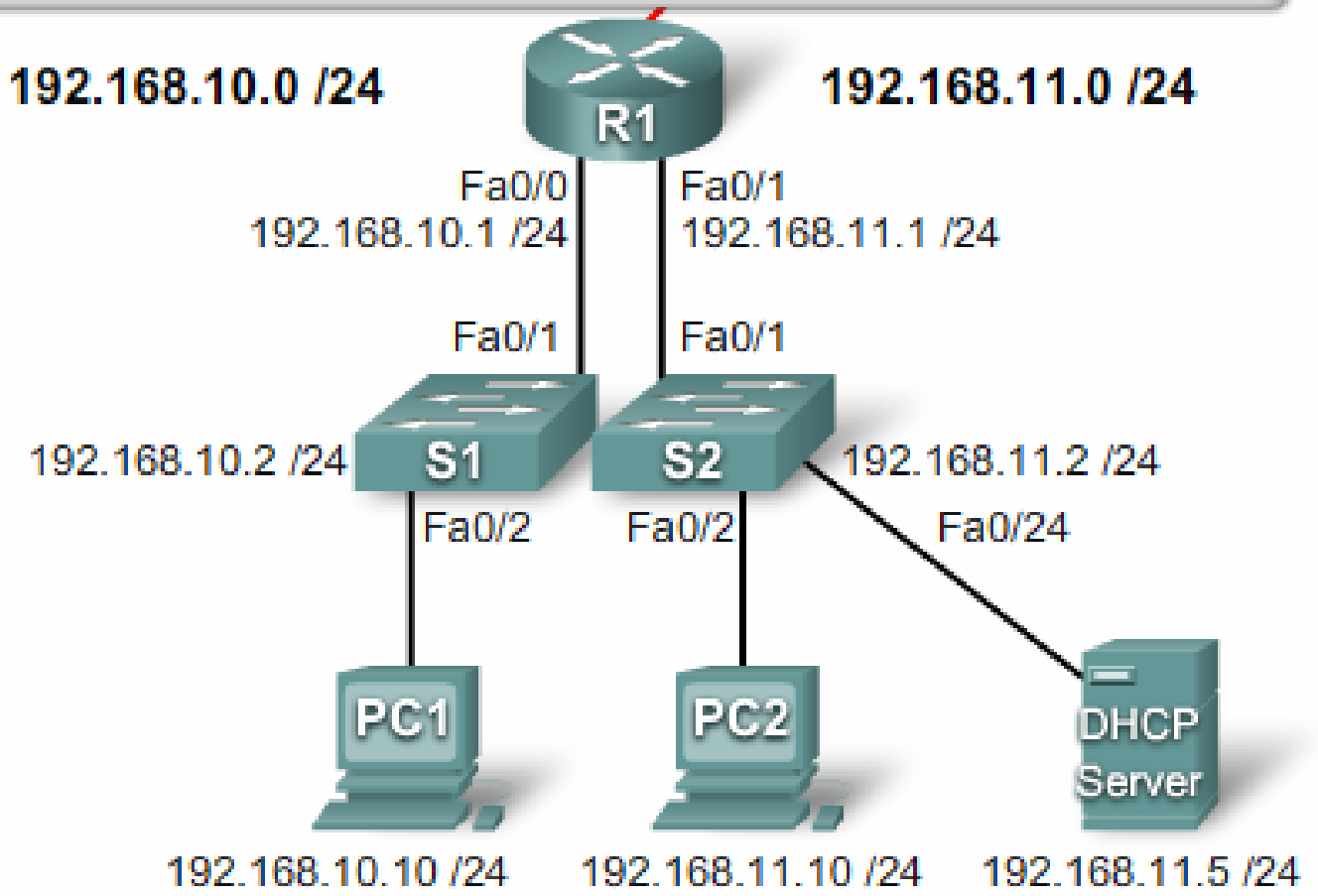
Host Problem

DHCP Relay



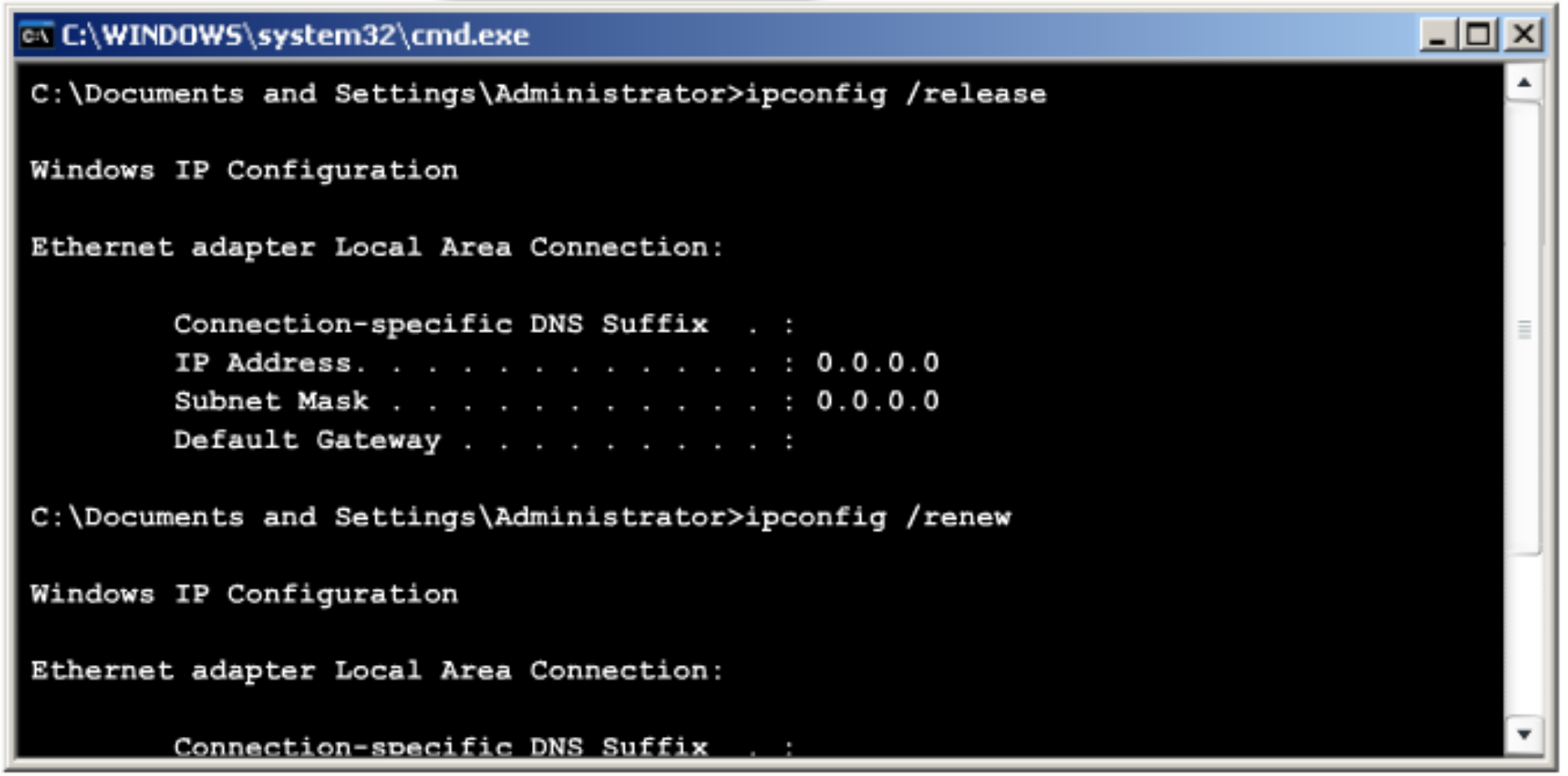
DHCP Relay

```
R1# config t
R1(config)# interface Fa0/0
R1(config-if)# ip helper-address 192.168.11.5
R1(config-if)# end
```



Host Renew

DHCP Relay



Troubleshooting DHCP Configurations

Troubleshooting DHCP	
Troubleshooting Task 1:	Resolving IP Address Conflicts
Troubleshooting Task 2:	Verify Physical Connectivity
Troubleshooting Task 3:	Test Network Connectivity by Configuring Client Workstation with a Static IP Address
Troubleshooting Task 4:	Verify Switch Port Configuration (STP Portfast and Other Commands)
Troubleshooting Task 5:	Distinguishing whether DHCP Clients Obtain IP Address on the Same Subnet or VLAN as DHCP Server

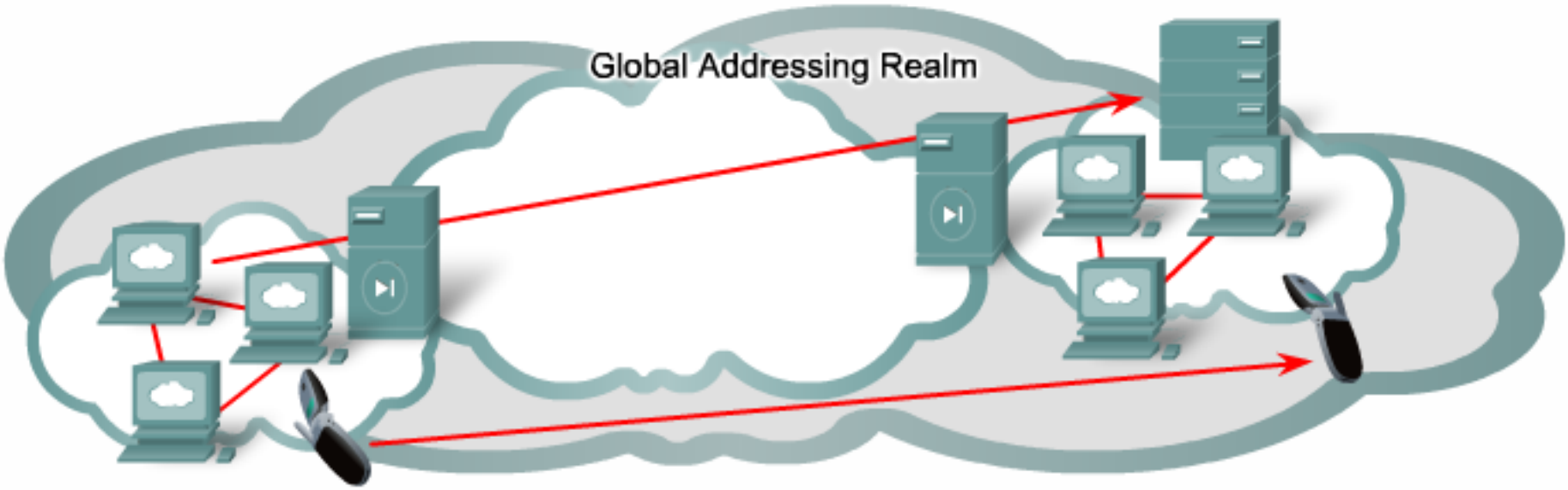
Verifying DHCP Relay

```
R1#show running-config

<Output omitted>
!
interface FastEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 ip helper-address 192.168.11.5
 duplex auto
 speed auto
!
<Output omitted>
```

Debugging DHCP Using Router debug Commands

```
R2# access-list 100 permit ip host 0.0.0.0 host 255.255.255.255
R2# debug ip packet detail 100
IP packet debugging is on (detailed) for access list 100
R2#
00:16:46: IP: s=0.0.0.0 (Ethernet4/0), d=255.255.255.255, len 604, rcvd 2
00:16:46: UDP src=68, dst=67
00:16:46: IP: s=0.0.0.0 (Ethernet4/0), d=255.255.255.255, len 604, rcvd 2
00:16:46: UDP src=68, dst=67
```

Why Do We Need a Larger Address Space?



Only compelling reason: more IP addresses!

- For billions of new users and new consumer devices (Asia, Europe and America) and (mobile phones, cars, PDAs, home and industrial appliances, ...)
- For always-on access (cable, xDSL, wireless, Ethernet-to-the-home, ...)
- For applications that are difficult, expensive, or impossible to operate through NAT (IP telephony, IP Fax, peer-to-peer gaming, home servers, ...)

Population growth **Mobile users** **Transportation** **Consumer electronics**

Japan, Korea, China, and Malaysia started the move in 2000

IPv4 and IPv6 Addresses

IPv4: 4 octets
11000000.10101000.11001001.01110000
192.168.10.101
4,294,467,295 (2^{32}) IP addresses

IPv6: 16 octets
11010001.11011100.11001001.01110001.11011100. 11001100.01110001.11010001.11011100.11001001. 11010001.11011100.11001001.01110001
A524:72D3:2C80:DD02:0029:EC7A:002B:EA73
3.4 x 10^{3} IP addresses

IPv4 and IPv6 Addresses

340,282,366,920,938,463,463,374,607,431,768,211,456

- There are so many IPv6 addresses available that many trillions of addresses could be assigned to every human being on the planet.
- There are approximately 665,570,793,348,866,943,898,599 addresses per square meter of the surface of the planet Earth!

IPv5 was used to define an experimental real-time streaming protocol. To avoid any confusion, it was decided to not use IPv5 and name the new IP protocol IPv6.

IPv6 Address Representation

Enhanced IP addressing:

- Global reachability and flexibility
- Aggregation
- Multihoming
- Autoconfiguration
- Plug-and-play
- End-to-end without NAT
- Renumbering

Multihoming is a technique to increase the reliability of the Internet connection of an IP network. With IPv6, a host can have multiple IP addresses over one physical upstream link. For example, a host can connect to several ISPs.

Autoconfiguration that can include data link layer addresses in the address space.

Mobility and security:

- Mobile IP RFC-compliant
- IPsec mandatory (or native) for IPv6

Simple header:

- Routing efficiency
- Performance and forwarding rate scalability
- No broadcasts
- No checksums
- Extension headers
- Flow labels

Transition richness:

- Dual-stack
- 6to4 and manual tunnels
- Translation

Transition richness:

IPv6 Address Representation

Enhanced IP addressing:

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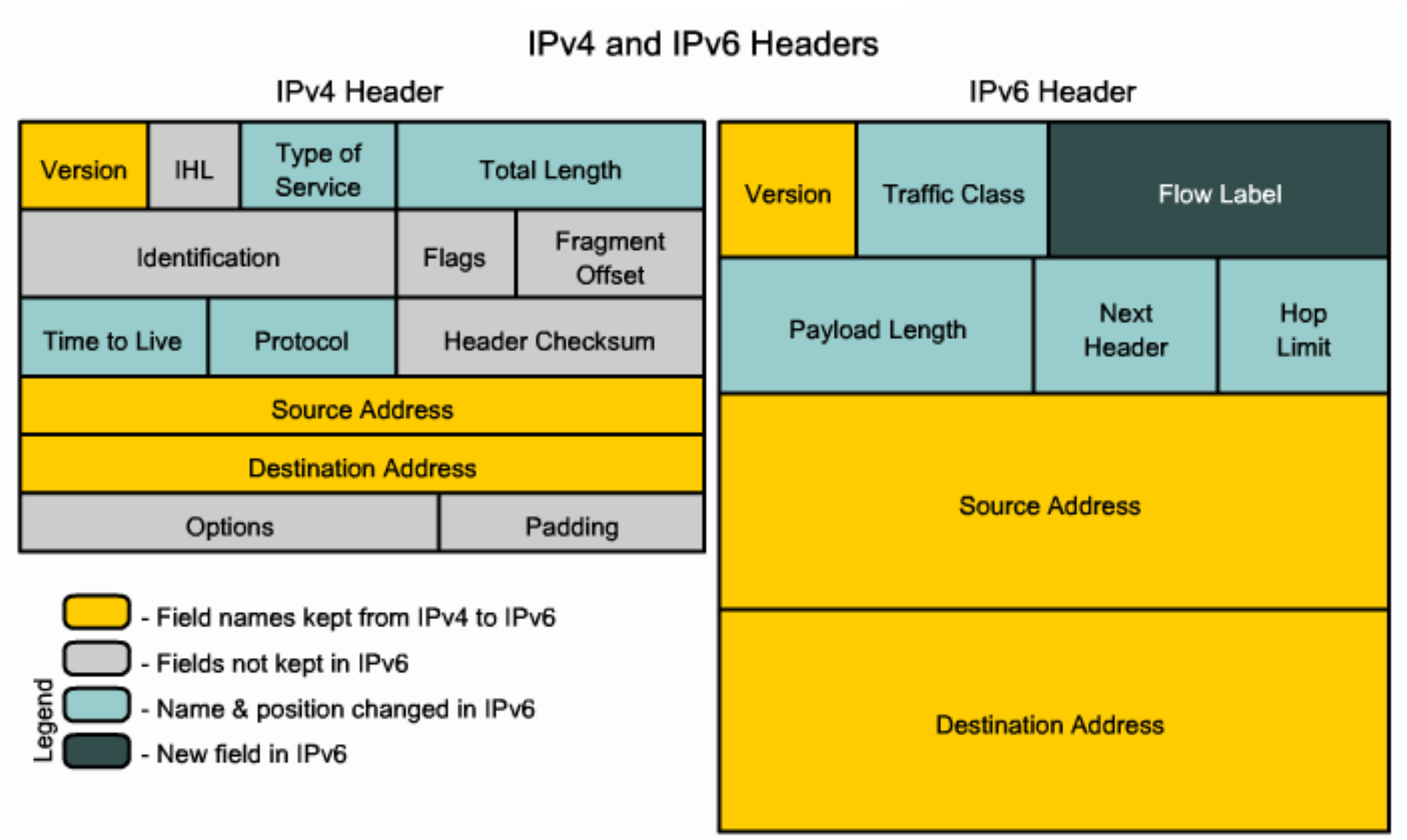
- Performance and forwarding rate scalability
- No broadcasts
- No checksums
- Extension headers
- Flow labels

Transition richness:

- **The IETF Mobile IP standard is available for both IPv4 and IPv6.**
- **The standard enables mobile devices to move without breaks in established network connections.**
- **Mobile devices use a home address and a care-of address to achieve this mobility.**
- **With IPv4, these addresses are manually configured.**
- **With IPv6, the configurations are dynamic, giving Ipv6-enabled devices built-in mobility.**

Transition richness:

- Dual-stack
- 6to4 and manual tunnels
- Translation


IPv4 and IPv6 Headers
IPv4 Header
Version
IHL
Type of Service
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source Address
Destination Address
Options
Padding
IPv6 Header
Version
Traffic Class
Flow Label
Payload Length
Next Header
Hop Limit
Source Address
Destination Address
Legend
- Field names kept from IPv4 to IPv6
- Fields not kept in IPv6
- Name & position changed in IPv6
- New field in IPv6

IPv6 Address Representation

IPv6 Formats

Format:

- `x:x:x:x:x:x:x:x`, where x is a 16-bit hexadecimal field
  - Case-insensitive for hexadecimal A, B, C, D, E, and F
- Leading zeros in a field are optional
- Successive fields of zeros can be represented as `::` only once per address

Examples:

- `2031:0000:130F:0000:0000:09C0:876A:130B`
  - Can be represented as `2031:0:130f::9c0:876a:130b`
  - Cannot be represented as `2031::130f::9c0:876a:130b`
- `FF01:0:0:0:0:0:0:1` `FF01::1`
- `0:0:0:0:0:0:0:1` `::1`
- `0:0:0:0:0:0:0:0` `::`

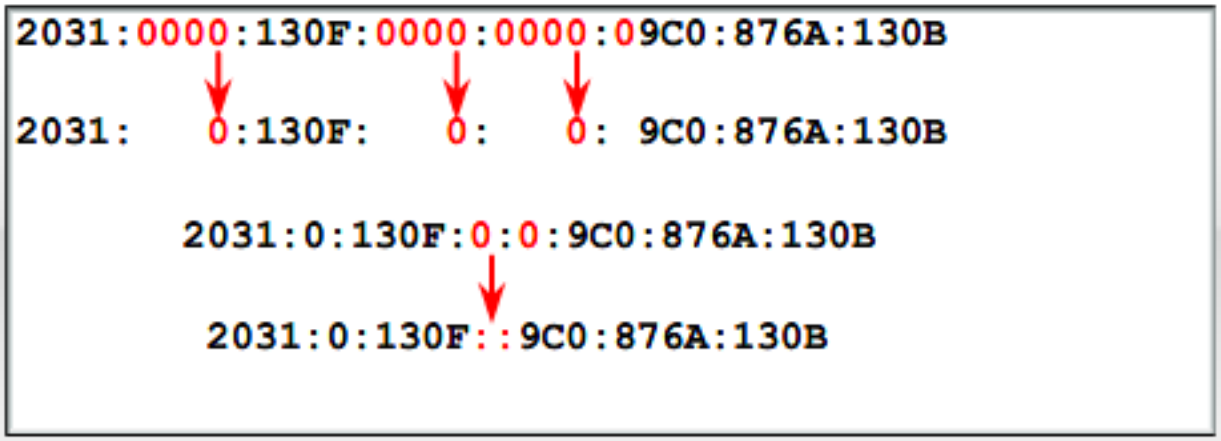
the all-zeroes address (0:0:0:0:0:0:0:0) is named the "unspecified" address. It is typically used in the source field of a datagram that is sent by a device that seeks to have its IP address configured. You can apply address compression to this address; because the address is all zeroes, the address becomes just "::".

IPv6 Address Representation

Representation

2031:0000:130F:0000:0000:09C0:876A:130B

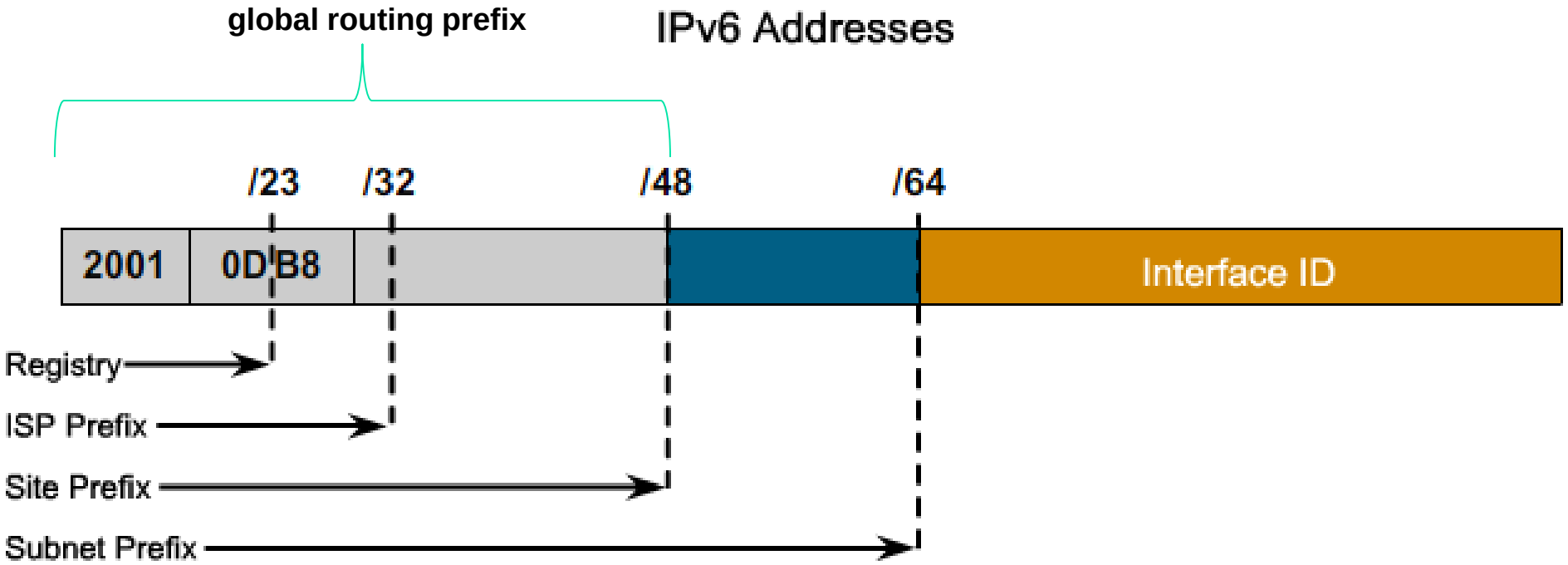
- Can be represented as 2031:0:130f::9c0:876a:130b
- But cannot be represented as 2031::130f::9c0:876a:130b



IPv6 Address Representation

Examples

- `FF01:0:0:0:0:0:0:1` becomes `FF01::1`
- `0:0:0:0:0:0:0:1` becomes `::1`
- `0:0:0:0:0:0:0:0` becomes `::`
- `FF01:0000:0000:0000:0000:0000:0000:1` becomes `FF01:0:0:0:0:0:0:1` becomes `FF01::1`
- `E3D7:0000:0000:0000:51F4:00C8:C0A8:6420` becomes `E3D7::51F4:C8:C0A8:6420`
- `3FFE:0501:0008:0000:0260:97FF:FE40:EFAB` becomes `3FFE:501:8:0:260:97FF:FE40:EFAB` becomes `3FFE:501:8::260:97FF:FE40:EFAB`



Private addresses have a first octet value of "FE" in hexadecimal notation, with the next hexadecimal digit being a value from 8 to F

site-local addresses begin with "FE" and then "C" to "F" for the third hexadecimal digit. So, these addresses begin with "FEC", "FED", "FEE", or "FEF".

Link-local addresses begin with "FE" and then have a value from "8" to "B" for the third hexadecimal digit. So, these addresses start with "FE8", "FE9", "FEA", or "FEB".

The loopback address is 0:0:0:0:0:0:0:1, which is normally expressed using zero compression as "::1".

Remember (IPv4)

- Link-Local Addresses: IPv4 addresses in the address block 169.254.0.0 to 169.254.255.255 (169.254.0.0 /16) are designated as link-local addresses.
- TEST-NET Addresses: The address block 192.0.2.0 to 192.0.2.255 (192.0.2.0 /24) is set aside for teaching and learning purposes.
- Although only the single 127.0.0.1 address is used, addresses 127.0.0.0 to 127.255.255.255 are reserved. Any address within this block will loop back within the local host. No address within this block should ever appear on any network.

Assigning IPv6 Addresses

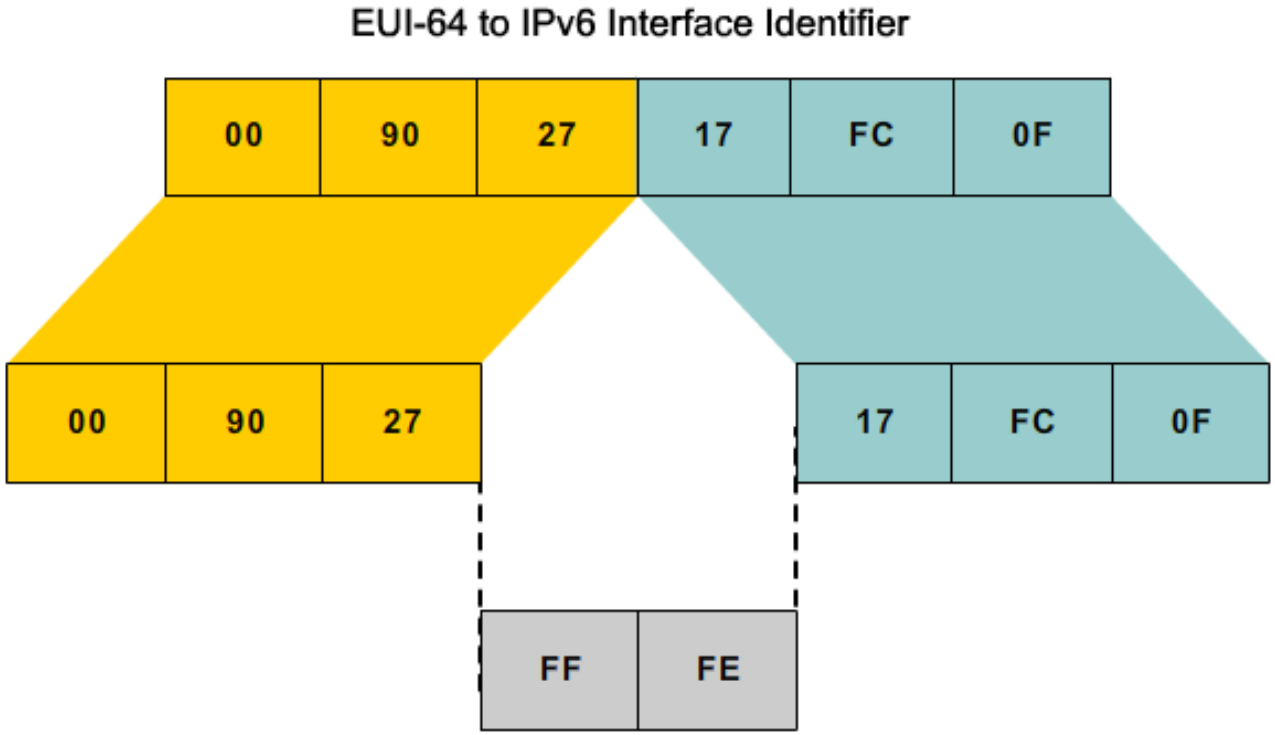
Static assignment	Dynamic assignment
• Manual interface ID assignment • EUI-64 interface ID assignment	• Stateless autoconfiguration • DHCPv6 (stateful)

To configure an IPv6 address on a Cisco router interface, use the ipv6 address ipv6-address/prefix-length command in interface configuration mode.

The following example shows the assignment of an IPv6 address to the interface of a Cisco router:

RouterX(config-if)#ipv6 address 2001:DB8:2222:7272::72/64

Extended Universal Identifier

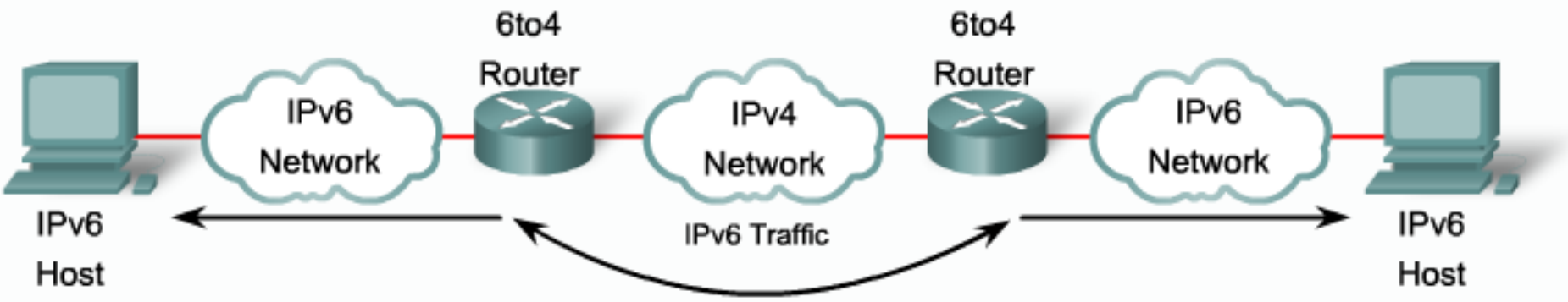


To configure an IPv6 address on a Cisco router interface and enable IPv6 processing using EUI-64 on that interface, use the ipv6 addressipv6-prefix/prefix-lengtheui-64 command in interface configuration mode.

The following example shows the assignment of an EUI-64 address to the interface of a Cisco router:

RouterX(config-if)#ipv6 address 2001:DB8:2222:7272::/64 eui-64

"Dual stack where you can, tunnel where you must."



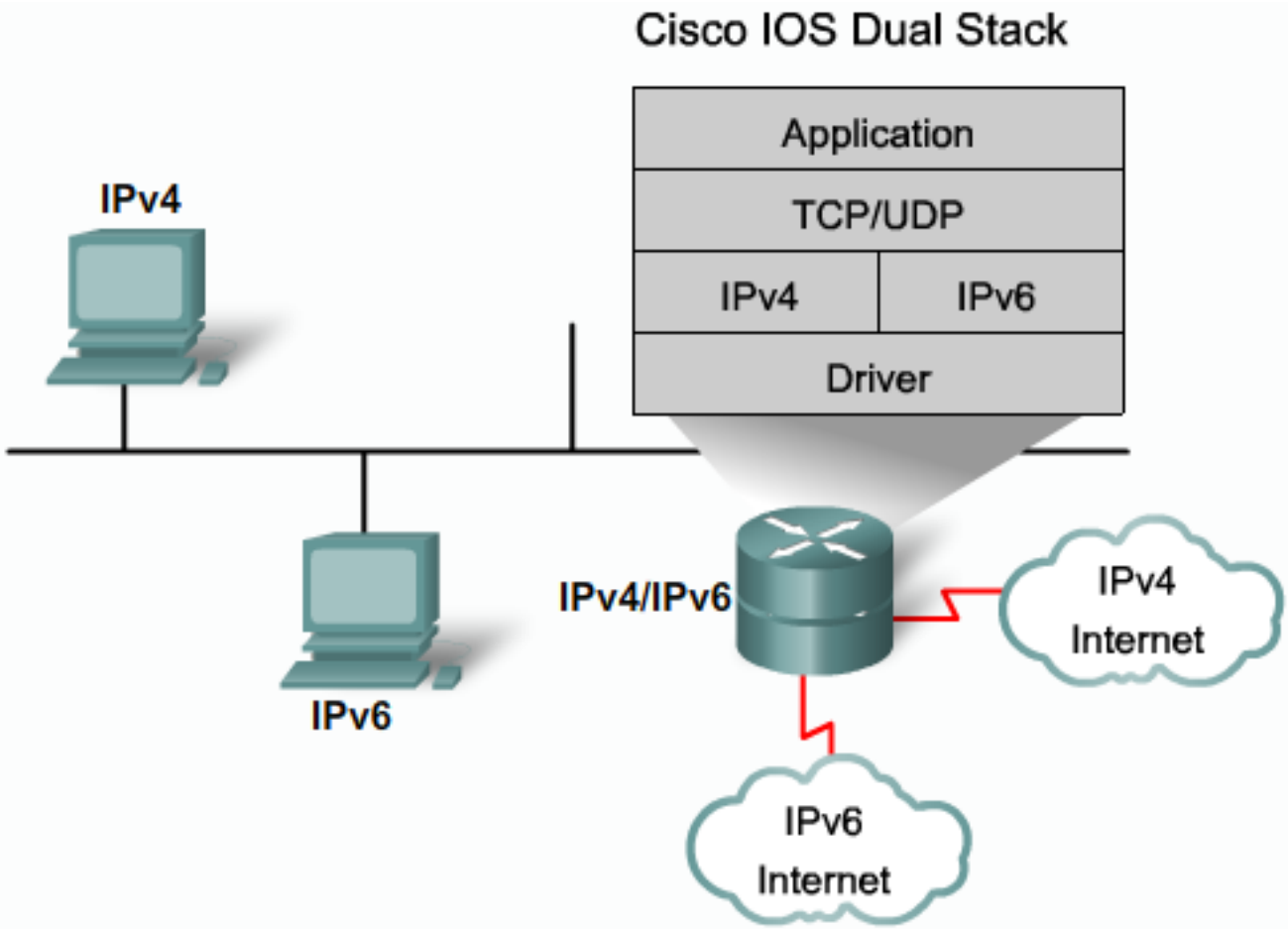
Different transition mechanisms are available:

- Dual stack
- Manual tunnel
- 6to4 tunnel
- ISATAP tunnel
- Teredo tunnel

Intra-Site Automatic Tunnel Addressing Protocol : uses the underlying IPv4 network as a link layer for IPv6.

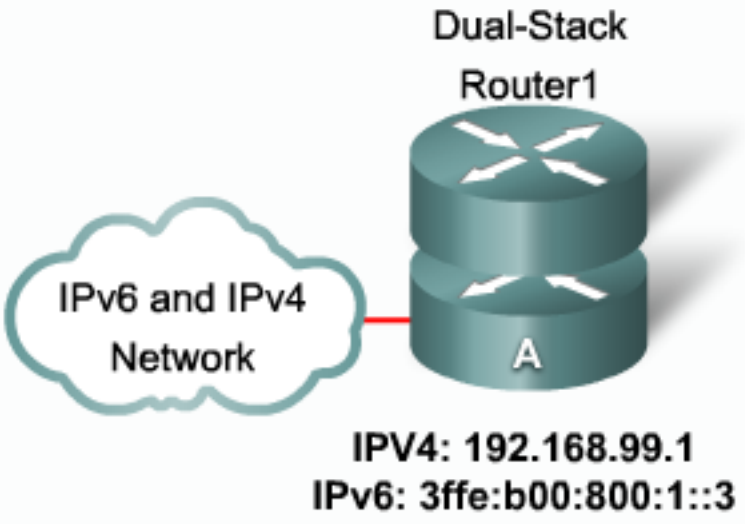
Different compatibility mechanisms:

- Proxying and translation (NAT-PT)



Dual stack is an integration method in which a node has implementation and connectivity to both an IPv4 and IPv6 network.

Cisco IOS Dual Stack

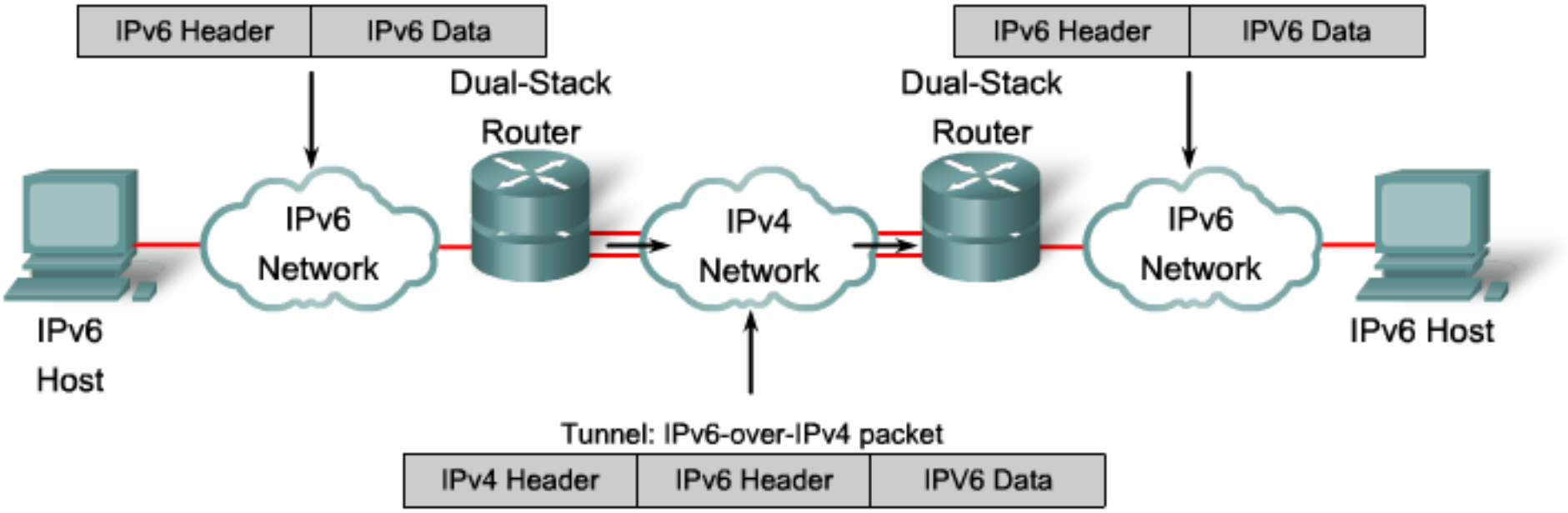



```
conf t
ipv6 unicast-routing

interface ethernet0
  ip address 192.168.99.1 255.255.255.0
  ipv6 address 3ffe:b00:c18:1::3/127
```

When both IPv4 and IPv6 are configured on an interface, the interface is considered dual-stacked.

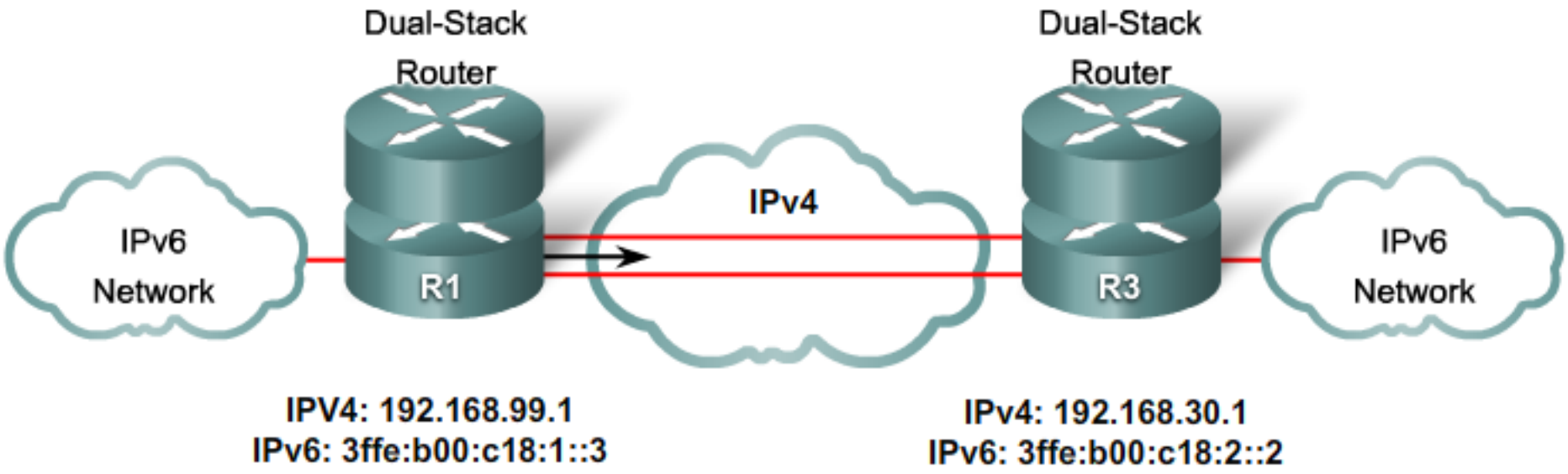
IPv6 Tunneling



Tunneling is an integration method in which an IPv6 packet is encapsulated within another protocol, such as IPv4. This method of encapsulation is IPv4:

- Includes a 20-byte IPv4 header with no options and an IPv6 header and payload
- Requires dual-stack routers

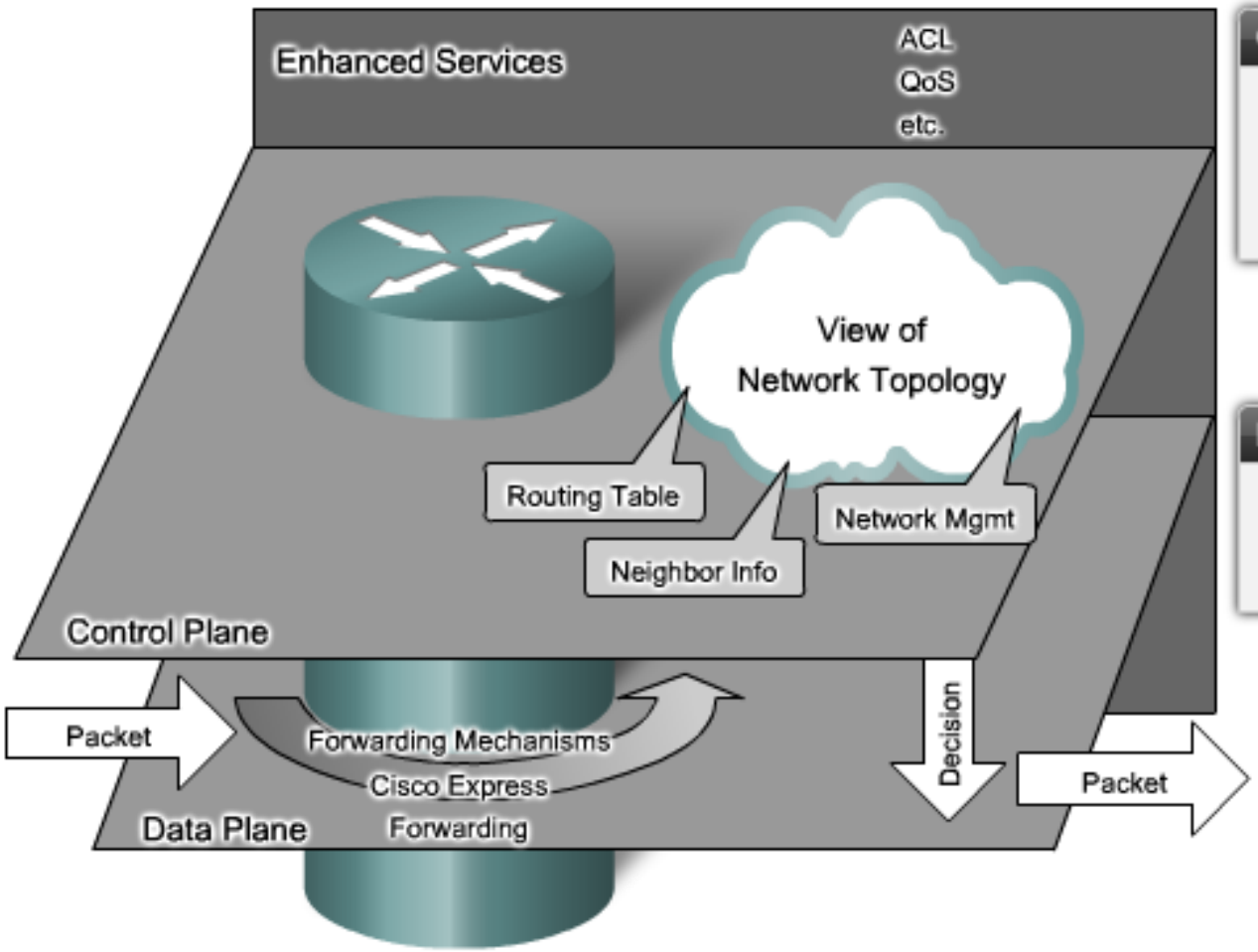
Manually Configured IPv6 Tunnel



Configured tunnels require:

- Dual-stack endpoints
- IPv4 and IPv6 addresses configured at each end

IPv6 Routing Considerations



Control Plane Considerations:

- IPv6 Address Size
- Multiple IPv6 Node Addresses
- IPv6 Routing Protocols
- Routing Table Size

Forwarding Plane Considerations:

- Parsing IPv6 Extension Headers
- IPv6 Address Lookup

RIPng Routing Protocol

Similar IPv4 features:

- Distance vector, radius of 15 hops, split horizon, and poison reverse
- Based on RIPv2

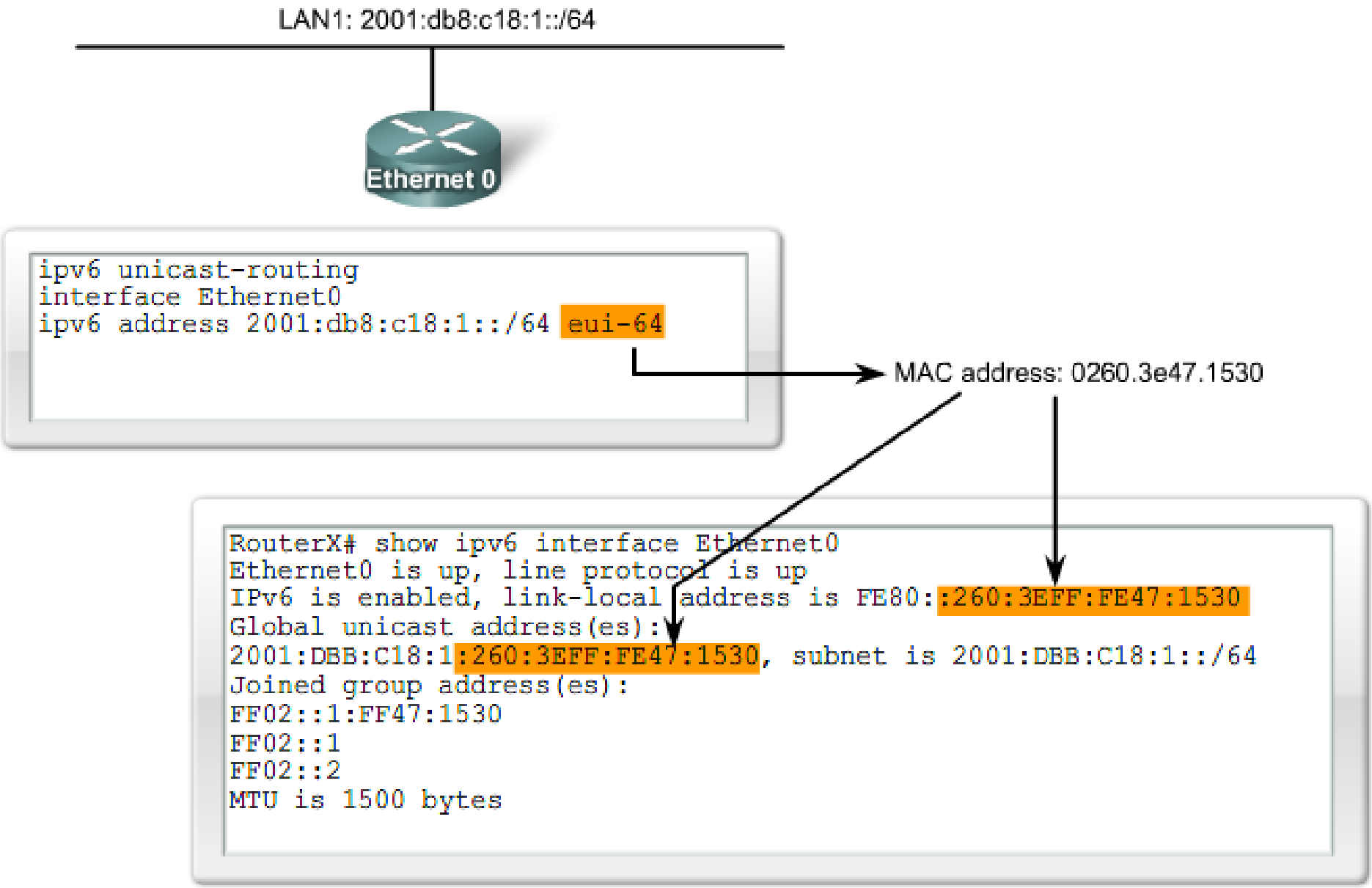
Updated features for IPv6:

- IPv6 prefix, next-hop IPv6 address
- Uses the multicast group FF02::9, the all-rip-routers multicast group, as the destination address for RIP updates
- Uses IPv6 for transport
- Named RIPng

Enabling IPv6 on Cisco Routers

Command	Purpose
`RouterX(config)#` `ipv6 unicast-routing`	Enables IPv6 traffic forwarding
`RouterX(config-if)#` `ipv6 address ipv6prefix/prefix-length eui-64`	Configures the interface IPv6 addresses

IPv6 Address Configuration Example



Cisco IOS IPv6 Name Resolution

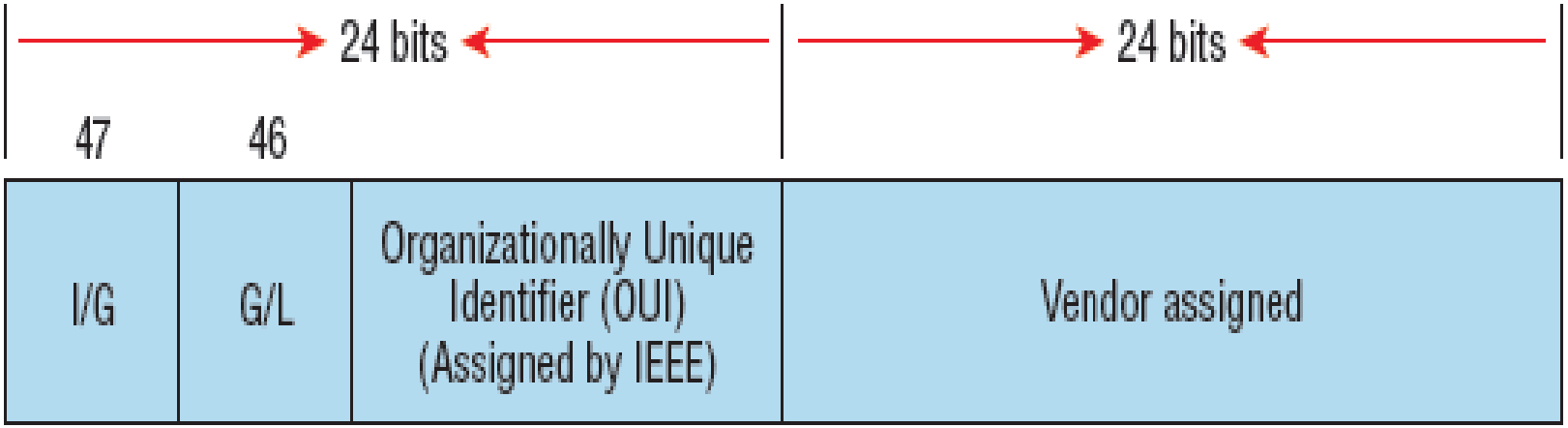
Two ways to perform Cisco IOS name resolution for IPv6:

Command	Purpose
RouterX(config)# **ipv6 host** *name* [*port*] *ipv6addr* [{*ipv6addr*} ...] RouterX(config)# **ipv6 host router1 3ffe:b00:ffff:b::1**	Define a static name for IPv6 addresses
RouterX(config)#**ip name-server** *address* RouterX(config)#**ip name-server 3ffe:b00:ffff:1::10**	Configure a DNS server or servers to query

Configuring RIPng for IPv6

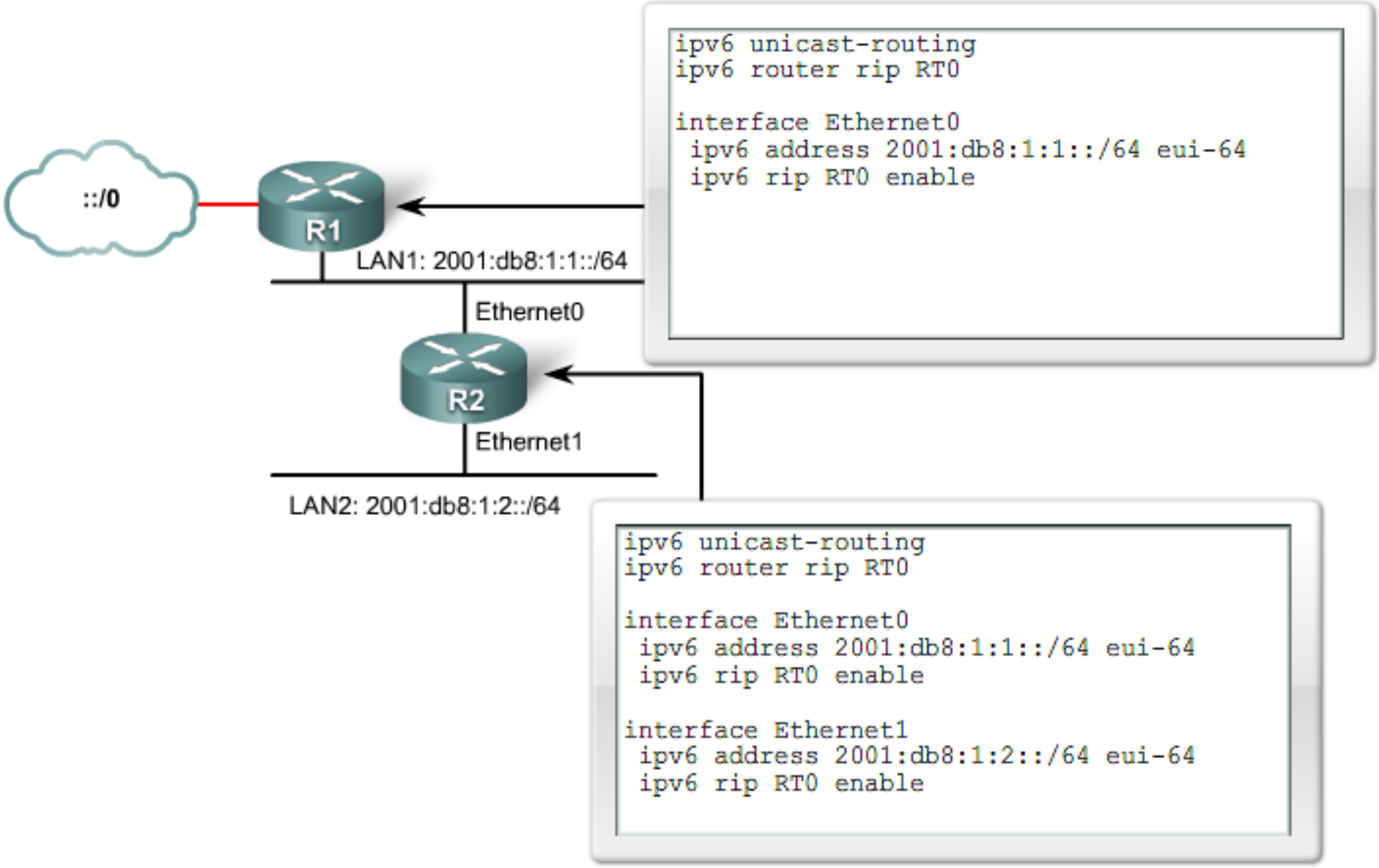
Command	Purpose
`RouterX(config)#ipv6 router rip name`	Creates and enters RIP router configuration mode.
`RouterX(config-if)#ipv6 rip name enable`	Configures RIP on an interface.

Ethernet addressing using MAC addresses



Example: 0000.0c12.3456

RIPng for IPv6 Configuration



Commands

Verifying

Command	Purpose
`show ipv6 interface`	Displays the status of interfaces configured for IPv6.
`show ipv6 interface brief`	Displays a summarized status of interfaces configured for IPv6.
`show ipv6 neighbors`	Displays IPv6 neighbor discovery cache information.
`show ipv6 protocols`	Displays the parameters and current state of the active IPv6 routing protocol processes.
`show ipv6 rip`	Displays information about the current
`show ipv6 route`	Displays the current IPv6 routing table.
`show ipv6 route summary`	Displays a summarized form of the current IPv6 routing table.
`show ipv6 routers`	Displays IPv6 router advertisement information received from other routers.
`show ipv6 static`	Displays only static IPv6 routes installed in the routing table.
`show ipv6 static 2001:db8:5555:0/16`	Displays only static route information about the specific address given.
`show ipv6 static interface serial 0/0`	Displays only static route information with the specified interface as the outgoing interface.
`show ipv6 static detail`	Displays a more detailed entry for IPv6 static routes.
`show ipv6 traffic`	Displays statistics about IPv6 traffic.

Commands

Troubleshooting

Command	Purpose
`clear ipv6 rip`	Deletes routes from the IPv6 RIP routing table and, if installed, routes in the IPv6 routing table.
`clear ipv6 route *`	Deletes all routes from the IPv6 routing table. NOTE: Clearing all routes from the routing table will cause high CPU use rates as the routing table is rebuilt.
`clear ipv6 route 2001:db8:c18:3::/64`	Clears this specific route from the IPv6 routing table.
`clear ipv6 traffic`	Resets IPv6 traffic counters.
`debug ipv6 packet`	Displays debug messages for IPv6 packets.
`debug ipv6 rip`	Displays debug messages for IPv6 RIP routing transactions.
`debug ipv6 routing`	Displays debug messages for IPv6 routing table updates and route cache updates.

Ethernet Addressing

- The *organizationally unique identifier (OUI)* is assigned by the IEEE to an organization.
- It's composed of 24 bits, or 3 bytes, and it in turn assigns a globally administered address also made up of 24 bits, or 3 bytes, that's supposedly unique to each and every adapter an organization manufactures.
- The high-order bit is the Individual/Group (I/G) bit.
- When it has a value of 0, we can assume that the address is the MAC address of a device and that it may well appear in the source portion of the MAC header.
- When it's a 1, we can assume that the address represents either a broadcast or multicast address in Ethernet.

Ethernet Addressing

- The next bit is the global/local bit, sometimes called the G/L bit or U/L bit, where *U* means *universal*.
- When set to 0, this bit represents a globally administered address, as assigned by the IEEE, but when it's a 1, it represents a locally governed and administered address.
- The low-order 24 bits of an Ethernet address represent a locally administered or manufacturer-assigned code.
- This portion commonly starts with 24 0s for the first card made and continues in order until there are 24 1s for the last (16,777,216th) card made.
- You'll find that many manufacturers use these same six hex digits as the last six characters
- of their serial number on the same card.

demilitarized zone (DMZ)

- The demilitarized zone (DMZ) can be global (real) Internet addresses or private addresses, depending on how you configure your firewall, but this is typically where you'll find the HTTP, DNS, email, and other Internet-type corporate servers.
- Instead of using routers, we can create VLANs with switches on the inside trusted network.
- Multilayer switches containing their own security features can sometimes replace internal (LAN) routers to provide higher performance in VLAN architectures.

A typical secured network